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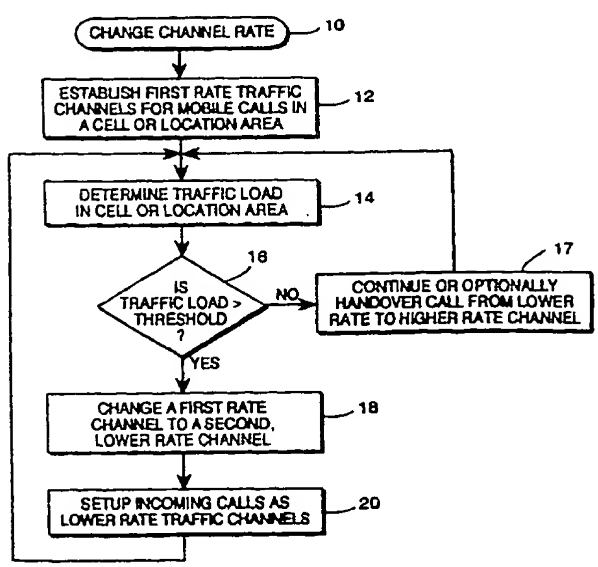
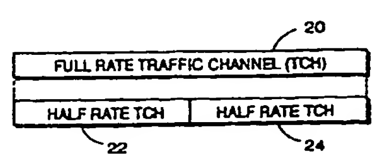
(54) Title: INCREASING TRAFFIC CAPACITY IN A CELLULAR COMMUNICATIONS SYSTEM BY CHANGE OF TRAFFIC CHANNEL RATE

(57) Abstract

The present invention dynamically increases the capacity of a cellular radio communications system to meet temporary high traffic demands effectively and economically. The current traffic load at a particular base station cell area is determined (14). If the determined traffic load exceeds a threshold (16), a higher rate traffic channel over which a dual rate mobile station is communicating is handed over to a lower rate traffic channel available in that cell area (18). A list is maintained for those dual rate mobile stations currently assigned to higher rate traffic channels. Before making the handover from the higher rate traffic channel to the lower rate traffic channel, it is determined whether a handover is permitted. If so, the intra-cell handover is preferably made to a traffic channel which is currently already supporting another lower rate call. Otherwise, any available lower rate traffic channel is assigned. At call setup, if the current traffic load in the cell area exceeds the threshold, a call request involving a dual rate mobile station is assigned a lower rate traffic channel (20). If the traffic load in the cell area decreases, a call intitially set up or subsequently handed over to a lower rate channel because of high traffic load may optionally be handed over to a higher rate channel (17).





INCREASING TRAFFIC CAPACITY IN A CELLULAR COMMUNICATIONS SYSTEM BY CHANGE OF TRAFFIC CHANNEL RATE

FIELD OF THE INVENTION

The present invention relates to increasing traffic capacity in a cellular radio communications system, and more particularly, to increasing traffic capacity by changing a requested or initially selected traffic channel rate to a lower bit rate when extra traffic capacity is needed.

BACKGROUND AND SUMMARY OF THE INVENTION

In the Global System for Mobile communications (GSM), two bit rates for speech coders are defined: full rate and half rate. Full rate corresponds to a bit rate of 13 kbits/s, and half rate corresponds to a bit rate of 6.5 kbits/s. A traffic channel in the GSM system can support one full rate speech call or two half rate speech calls. Speech coding significantly lowers the bit rate over the radio interface (higher bit rates take up too much of the frequency spectrum) while still providing acceptable speech quality. In general, speech coding sends information about the speech (rather than the speech itself) from which the speech signal can be reconstructed at the receiver.

The GSM also employs time division multiple access (TDMA) with each radio frequency carrier being divided into eight time slots (TS). One time slot in a TDMA frame is called a physical channel, and each duplex pair of frequency carriers includes eight physical channels. Speech and other information are sent on logical traffic channels (TCH) mapped onto the physical time slot channels. In full rate traffic channels, a user is assigned a single physical channel/time slot. For half rate traffic channels, two mobile stations share the same physical channel/time slot with each mobile station alternating use of the allocated time slot.

Mobile telephone system operators live in a highly competitive world. To be successful, a mobile telephone system operator must deliver:

- Coverage -- a call can be set up anywhere
- Capacity -- a call can be set up anytime
- Quality -- the call is clear, undisturbed, and uninterrupted.

The present invention addresses capacity.

The traditional approach to increasing capacity is to equip base stations with as many transceivers as possible and to invest in high capacity base station controllers. While this is a sound strategy in densely populated areas with evenly distributed traffic demands over time, in areas where the traffic demand is high only during short periods, e.g., certain streets during morning and evening rush hour, that strategy is less sound. The more difficult issue is how to satisfy temporary high traffic demands effectively and economically.

Thus, it is a primary object of the invention to dynamically increase system capacity to meet temporary high traffic demands in an effective and economic fashion.

It is a further object of the invention to provide enhanced ability to provide service for connections requiring a full rate traffic channel.

Some percentage of mobile stations currently (and with increasing numbers in the future) are capable of transceiving at different bit rates. For purposes of explaining the present invention, (and not in any way limiting the present invention), some mobile stations are assumed to be capable of transceiving on both full rate and half rate channels. Such mobile stations are referred to as having "dual rate" capability. Dual rate mobiles indicate their dual rate capability to the cellular network via an initial channel request message or possibly in periodic registration messages. Higher rate

channels may be used in favorable traffic conditions but half rate channels are employed during temporary high traffic conditions.

The present invention increases the capacity in a cellular radio communications system in accordance with the following method. Initially, a higher rate traffic channel is established for communication with a mobile station located in a particular cell area. The current traffic load at that cell area is determined. If the determined traffic load exceeds a threshold, the higher rate traffic channel over which a dual rate mobile station is communicating is handed over to another lower rate traffic channel available in that cell area. For currently active traffic channels, a list is maintained for those dual rate mobile stations currently assigned to higher rate traffic channels.

Before making the handover from the higher rate traffic channel to the lower rate traffic channel, it is determined whether such a handover is permitted. If so, the intra-cell handover is preferably made to a traffic channel which is currently already supporting another lower rate call. Otherwise, any available lower rate traffic channel is assigned.

At call setup, if the current traffic load in the cell area exceeds the threshold, a call request involving a dual rate mobile is assigned a lower rate traffic channel. If the traffic load in the cell area decreases, a call initially setup or subsequently handed over to a lower rate channel because of high traffic load may be handed over to a higher rate channel.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features, and advantages of the invention will be apparent from the following description of preferred embodiments as illustrated in the accompanying drawings in which reference characters refer to the same parts

throughout the various views. The drawings are not necessarily to scale with emphasis being placed upon illustrating the principles of the invention.

Fig. 1 is a flowchart illustrating a general "change channel rate" procedure in accordance with a first example embodiment of the present invention;

Fig. 2 is a function block diagram of a GSM-type mobile radio communications system in which the present invention may be incorporated in accordance with a second example embodiment of the present invention;

Fig. 3 is a diagram conceptually depicting a traffic channel supporting a single full rate channel or two half rate channels;

Fig. 4 are more detailed function block diagrams of specific blocks shown in Fig. 2; and

Figs. 5A and 5B are flowcharts illustrating example procedures in accordance with the second example embodiment of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

In the following description, for purposes of explanation and not limitation, specific details are set forth, such as particular embodiments, hardware, techniques, etc. in order to provide a thorough understanding of the invention. However, it will be apparent to one skilled in the art that the present invention may be practiced in other embodiments that depart from these specific details. For example, while a specific embodiment of the present invention is described in the context of a GSM cellular telephone network, those skilled in the art will appreciate that the present invention can be implemented in any cellular telephone system. In other instances, detailed

descriptions of well-known methods, interfaces, devices, and signaling techniques are omitted so as not to obscure the description of the present invention with unnecessary detail.

Because the application is applicable to any cellular telephone communications systems, a first example embodiment of the present invention is now described in general terms. The flowchart in Fig. 1 outlines the steps of a Change Channel Rate routine (block 10). Assuming a light or moderate traffic load initially, traffic channels are established for mobile calls in a particular cell, sector, or other location area at a first traffic rate (block 12) in accordance with normal channel request and assignment procedures. The traffic load in the cell or location area is determined (block 14). A decision is made in block 16 whether the traffic load for that cell or location area exceeds a threshold, i.e., whether there has been temporary increase in traffic demand. If not, the mobile communications continue as set up (block 17). However, if the traffic load exceeds a threshold, a dual rate mobile communication being conducted over a traffic channel at a first rate is handed over to another traffic channel where the communication is conducted a second lower rate (block 18). Moreover, new incoming calls for dual rate mobiles are set up as lower rate calls rather than higher rate calls until the traffic load decreases below the threshold. If the traffic load decreases significantly, calls may optionally be handed over from lower rate traffic channels to available higher rate traffic channels (block 17).

Thus, the present invention provides a temporary increase of the traffic capacity of a cell by utilizing lower rate capabilities of some dual rate mobile stations operating in the cell. Because the communication connections are moved within the serving cell, i.e., intra-cell handoffs, there is no increase in interference level that might be experienced if inter-cell handoffs to other cells were employed. Another advantage of the present invention is that no additional hardware is required. Reserve but often underutilized base station transceivers are not needed to ensure sufficient capacity for

temporary high traffic demands. Yet another advantage of this invention is that a mobile communications network operator can control how the traffic demands of each cell are handled by changing the traffic load threshold to appropriate values. An appropriately-valued threshold ensures that only a minimum number of mobile stations having dual rate capability are affected by intra-cell handovers to lower rate traffic channels during high traffic conditions. The present invention also selects the channel rate for a particular traffic channel at call setup based on a current cell traffic load level so that during periods of high traffic, communications involving dual rate mobile stations are established using lower rates to further increase traffic capacity.

A second example embodiment of the present invention will now be described as applied to a GSM-based cellular communications system. However, those skilled in the art will appreciate that the present invention is in no way limited to GSM-based cellular communications systems.

Reference is made to Fig. 2 which illustrates in function block format a typical GSM-based cellular communications system 30. A Gateway Mobile Switching Center (GMSC) 36 interfaces the cellular communications network with other telecommunications networks including the Public Switched Telephone Network (PSTN) 32, the Internet 34, other cellular networks, and other types of communications networks such as the Integrated Services Digital Network (ISDN). The Gateway Mobile Switching Center 36 connects to one or more Mobile Switching Centers (MSCs) 38. Each mobile switching center 38 is connected to one or more base station controllers (BSCs) 42. The BSC handles all radio related functions including administration and remote control of the base stations 44 as well as the handling of connections to mobile stations 46 including handovers. Each BSC 42 is connected to plural base stations (BSs) 44 that communicate with mobile radio stations (MS) 46.

The gateway MSC 36 is the interface point in the mobile radio network for calls to mobile subscribers. Although the GMSC 36 is shown as a separate node for clarity of illustration, it may be located with an MSC 38. Each mobile switching center 38 performs telephony switching functions associated with calls involving a mobile station (MS) 46 including interfacing with other telecommunications networks 32 and 34 and routing mobile-originated calls.

Each MSC 38 is associated with a Visiting Location Register (VLR) 40 which includes a database containing temporary subscriber information needed by its associated MSC 38 to provide services to mobile stations in the MSC's service area. Typically, when a mobile station enters a visiting network or service area, it registers with the VLR 40 which then requests and receives data about the roaming mobile station from the mobile's Home Location Register (HLR) 41 and stores it. As a result, when the visiting mobile station is involved in a call, the VLR 40 already has the information needed for call setup. While the VLR 40 may be a stand-alone node, it is preferably integrated with its associated MSC to eliminate signaling between the two nodes.

The home location register (HLR) 41 is a database node that stores and manages subscriptions. For each "home" mobile subscriber, the HLR 41 contains permanent subscriber data such as the Mobile Station ISDN Number (MSISDN) which uniquely identifies the mobile telephone subscription in a PSTN numbering plan, and an international mobile subscriber identity (IMSI), which is a unique identity allocated to each mobile subscriber and used for signaling for in the mobile network. All network-related subscriber information is connected to the IMSI. The HLR 41 contains a list of services which a mobile subscriber is authorized to use along with the current subscriber location number corresponding to the address of the VLR 40 currently serving the mobile subscriber.

Once a serving MSC/VLR is identified (in the home or in a visiting network), a call intended for the mobile station 46 is routed by that serving MSC to a base station 44 associated with the cell in which the called mobile station is currently located. Using well-known, established protocols and procedures documented in various GSM standards, a call connection is established over the radio interface between the base station 44 and the mobile station 46.

During a call setup, a logical traffic channel is allocated to a radio connection between a base station and mobile station based on information about the available channel's characteristics, and in the present invention in particular, based on the mobile station's capabilities. When the connection has been established over an assigned traffic channel, e.g., a TDMA time slot, signal strength and speech quality are monitored and forwarded to the BSC which may initiate a handover of the connection based on those reports.

When a call is initiated, it is the BSC that allocates an available traffic channel (TCH) to the mobile station. In current GSM systems, a traffic channel (TCH) can either support a single full rate communication such as shown at 50 in Fig. 3 or two half rate communications as indicated at 22 and 24 in Fig. 3. An example full rate communication corresponds to a bit rate of 13 kbits/s, and an example half rate communication corresponds to a bit rate of 6.5 kbits/s. It is understood that reference to a full rate traffic channel means a traffic channel currently supporting a single full rate call, and reference to a half rate traffic channel means a traffic channel currently supporting one or two half rate calls.

More detailed block diagrams of the BSC 42, base station 44, and a dual rate mobile station 46 are now described in conjunction with Fig. 4. For purposes of illustration and description only, function blocks are shown. However, those functions

may be performed using any suitable electronic circuitry including DSP, AGIC, suitably programmed main processor, etc.

The traffic load in each base station's cell, sector, or location area is monitored by the BSC 42. However, this operation or function may be performed by other entities such as the MSC 38, each bases station, or other radio network control entity. The BSC 42 includes a traffic load detector 50 which, in this simplified example, monitors the traffic load in area X serviced by a base station 44. The BSC 42 performs similar tasks for each such area for each base station under its control. Traffic load detector 50 includes a comparator 52 and a busy full rate traffic channel (TCH) counter 54. Counter 54 is incremented and decremented to track a current total number of busy traffic channels for that call area "X". A traffic channel is considered busy if it is unavailable to support a full rate call, i.e., the channel is partly or completely allocated for circuit-switched or packet-switched traffic. The output of counter 54 is input to comparator 52 along with a threshold value (T) which may correspond to a certain number of traffic channels set by the mobile network operator. When the output of the counter exceeds the threshold, the comparator generates a traffic load signal which may be used to set a high load flag in controller 56 for cell area X. Preferably, the threshold value (T) incorporates hysteresis to minimize undesired channel rate switching. Thus, controller 56 receives channel requests from various base stations 44 and issues channel assignments for various mobile communications to the base stations. Controller 56 accesses a memory 58 to store a list of dual rate capable mobile stations currently assigned to a full rate traffic channel. In executing various channel assignments and channel drops, controller 56 increments and decrements, respectively, the busy full rate TCH counter 54 for each base station area.

Each base station 44, such as the base station shown for cell area X, includes numerous transceivers used to establish and maintain various channels over the radio

interface with mobile stations 46 being serviced in area X. A simplified example of a base station transceiver shown in block 44 includes baseband processing circuitry 60 switchably connected via switch 62 to one of a full rate encoder/decoder 64 and a half rate encoder/decoder 66 also switchably connected at an opposite terminal via switch 70 to transceiving circuitry 72 and antenna 76. A base station controller 74 performs a number of base station control operations including setting the position of switches 62 and 70 depending on whether a particular communication is to be conducted over a traffic channel at full rate or half rate.

The dual rate mobile station 46 shown in Fig. 4 includes, among other elements, baseband processing circuitry 80 switchably connected via switch 82 to one of a full rate encoder/decoder 84 and a half rate encoder/decoder 86 also switchably connected at their respective output terminals via switch 88 to transceiving circuitry 90 and antenna 94. A dual rate mobile station controller 92 performs a number of control functions including controlling the position of switches 82 and 88 depending upon whether a full rate or a half rate channel assignment (initially or as a result of a handover) is received by the mobile station.

The operation of the second example embodiment of the present invention is now described in conjunction with the flowchart illustrated in Fig. 5A. It is understood that change of channel rate is supported and permitted by the base station as well as by at least some of the mobile stations currently being served by that base station. Change of channel rate may be blocked if it is not supported or permitted. For example, certain types of calls such as data calls which are initially assigned to a full rate call may not in some instances be permitted to be changed to a half rate call after the call is initially set up as a full rate connection.

The first step is for the traffic load detector to determine the traffic load corresponding in this second embodiment to the number of currently-assigned, full rate

traffic channels (block 100) using the output from the busy full rate counter 54, the threshold input, and the comparator 52 in the traffic load detector 50. A decision is made in block 102 whether the current traffic load exceeds the threshold (which preferably incorporates a hysteresis value). If not, control loops back to block 100 to monitor the traffic load with no change of channel rate being necessary at this time.

If the traffic load in this cell area exceeds the threshold, the BSC controller 56 generates a list 58 of dual rate mobile stations in this cell area X that are currently assigned to a full rate traffic channel that are permitted to use a half rate traffic channel if necessary (block 106). A decision is made in block 108 by controller 56 whether there are any dual rate mobile stations included in the list. If not, control returns back to block 100 to repeat the above procedures.

However, if there are dual rate mobile stations currently assigned to a full rate traffic channel entered on the list, another decision is made in block 110 whether any traffic channel associated with the base station for area X has one half rate connection idle. As described above in conjunction with Fig. 3, a traffic channel can support two half rate traffic channel connections. It is more efficient to fully occupy that traffic channel with two half rate calls. A handover of the current call on the full rate traffic channel for the dual rate mobile station at the top of the list is handed over to the remaining idle half rate connection (block 112). The handover frees up a full rate traffic channel for other call requests some of which may require a full rate traffic channel during this high traffic demand period. Alternatively, the freed up full rate channel may be used to support two new half rate call connections.

The BSC controller 56 generates the necessary handover commands for the base station controller 74 and mobile station controller 92. When the mobile station 46 initially sends a "channel request" message to its serving base station, the base station includes the channel request message with a "channel required" message sent to the

BSC. A portion of the channel request indicates the types of channels over which the mobile station can communicate, e.g., full rate, half rate, etc. A "channel assignment" command is then sent to the mobile station from the BSC via the serving base station containing a channel description of an initial or a new half rate traffic channel for which the call is to be established or handed over. The base station activates the new half rate traffic channel. For handovers, when the new traffic channel is acknowledged, the BSC controller 56 sends a message to the mobile station via the old full rate traffic channel with information about the new half rate traffic channel frequency, time slot, and output power. The mobile station tunes to the new frequency and sends handover access bursts on the appropriate time slot. Once those bursts are detected and acknowledged, a handover complete message is transmitted by the mobile, and the old full rate traffic channel is deactivated making it available for assignment to other communications.

On the other hand, if there are no traffic channels supporting a current half rate connection with the other half rate connection idle, a decision is made in block 114 whether there is any traffic channel with both half rate channel connections idle, i.e., a traffic channel that is available to support one full rate connection or two half rate connections. If not, then the list of dual rate mobile stations 58 is cleared (block 122), and the process repeats at block 100. On the other hand, if there is an available half rate channel connection, a handover is executed for the mobile station at the top of list 58 from a current full rate connection to a new half rate connection on the idle traffic channel identified in block 114 (block 116). When the handover is performed in either blocks 112 or 116, the mobile station entry at the top of the list 58 is removed (block 118). A decision is then made in block 120 whether the traffic load is less than the threshold by a hysteresis amount. If not, if the cell is still experiencing high traffic conditions and may add additional capacity by changing the channel rate from full rate to half rate connections. On the other hand, if the traffic load has decreased sufficiently

beneath the threshold, the list is cleared in block 22, and the process repeated starting at block 100.

If the traffic load exceeds the threshold in decision block 102, the BSC controller 56 also attempts to increase capacity by assigning half rate traffic channels where permitted/possible for new call requests, see flags A in Fig. 5A, and described in the flowchart illustrated in Fig. 5B. For a high traffic load condition, each new channel request is received (block 130), and the rate capability of the mobile station associated with the channel request is determined (block 132) based on the indication of what kinds of channels the mobile station can handle contained in the channel request message. If a full rate traffic channel is required, (for whatever reason), the channel setup is continued to assign a full rate traffic channel assuming that one is available. However, if a full rate traffic channel is not required for the current call request, a half rate traffic channel is assigned (block 136) and control returns to block 100 in Fig. 5. When the traffic load is detected to have decreased sufficiently, an optional procedure is to permit ongoing half rate calls to be selectively handed over to available full rate channels.

Consider the following simple example. Assume that the base station 44 has a total of four transceivers where each transceiver includes eight time slot channels. Accordingly, the base station includes a total of thirty-two time slots of which three are used for control channel signaling leaving twenty-nine time slots for traffic channels. Again, all base station transceivers are assumed to be capable of carrying full rate and half rate channels. Half of the mobile stations are assumed to be capable of dual rate communications with the other half being capable of full rate communication only. The traffic load threshold is set to seventy-five percent with a hysteresis of five percent. Translated to a number of traffic channels for this example, the threshold is twenty-two busy traffic channels with a hysteresis of one traffic channel. Thus, a high load flag is

set when twenty-three or more traffic channels are currently busy, and is reset when less than twenty-one traffic channels are currently busy.

Assume that the traffic channels are currently used as follows: two traffic channels are allocated as packet data channels, ten traffic channels are occupied by mobile stations capable of full rate only, one traffic channel is occupied by two half rate calls, two traffic channels are occupied by one half rate call per each traffic channel, seven traffic channels are occupied by dual rate mobile stations currently using a full rate connection. In total, twenty-two traffic channels are busy, and therefore, the high traffic load flag is not set.

Suppose another full rate call is established for a dual rate mobile station. The high traffic load flag is then set. The base station controller 56 generates a list of dual rate mobile stations that are candidates for handovers. The list includes eight entries corresponding to the eight dual rate mobile stations currently using full rate connections. These full rate connections are handed over one at a time to a half rate channel until the high load situation is alleviated. For example, a first full rate connection is moved to an idle half rate connection on one of the partially-allocated traffic channels already carrying one half rate call connection. After this first handover, the number of busy traffic channels equals twenty-two, assuming that no new calls have been established, which is not low enough to reset the high load flag. A second connection is moved to the idle part of the second of the partially-allocated traffic channels. The number of busy traffic channels is reduced to twenty-one which again is not low enough to reset the high load flag. A third full rate connection is moved to a half rate channel on one of the idle full rate channels. A fourth connection is moved to the other available half rate connection on that same traffic channel.

By transforming the four full rate connections to four new half rate connections, the number of busy traffic channels is reduced from twenty-three to twenty. As a result,

four additional traffic channels are made available to service other calls at a relatively minimal cost of performing for intra-cell handoffs. Surges in traffic demands are efficiently met in dynamic fashion without additional base station transceivers.

While the present invention has been described with respect to particular embodiments, those skilled in the art will recognize that the present invention is not limited to the specific embodiments described and illustrated herein. Different formats, embodiments, and adaptations besides those shown and described, as well as many variations, modifications, and equivalent arrangements may also be used to implement the invention. Therefore, while the present invention has been described in relation to its preferred embodiments, it is to be understood that this disclosure is only illustrative and exemplary of the present invention and is merely for the purposes of providing a full and enabling disclosure of the invention. Accordingly, it is intended that the invention be limited only by the spirit and scope of the claims appended hereto.

WHAT IS CLAIMED:

1. A method for increasing capacity in a cellular communications system where mobile stations communicate over traffic channels, comprising the steps of:

establishing a first rate traffic channel for a communication with a mobile station located in a particular cell area;

determining a traffic load at the cell area; and

if the traffic load at the cell area exceeds a threshold, changing the first rate traffic channel to a second rate traffic channel.

2. The method in claim 1, further comprising:

if the traffic load at the cell area exceeds a threshold, setting up new second rate traffic channel in response to a channel request involving a mobile station in the cell area.

3. The method in claim 2, further comprising:

determining whether the mobile stations identified in the channel requests have the capability to communicate over a second rate channel before the setting up step.

4. The method in claim 1, wherein the first rate is a higher rate than the second rate.

5. The method in claim 1, further comprising:

determining whether the mobile station includes a dual rate capability to communicate using either one of the first and the second rates,

wherein the changing step includes determining whether the mobile station has the dual rate capability.

6. The method in claim 5, further comprising:

for a dual rate capable mobile station, determining whether change to a second rate channel communication is permitted.

7. The method in claim 1, wherein the changing step includes:

performing an intra-cell handover of the communication from the first rate traffic channel to the second rate traffic channel.

8. The method in claim 1, wherein the second rate is corresponds to a bit rate of 6.5 kbits/s and the first rate corresponds to a bit rate of 13 kbits/s.

9. The method in claim 1, wherein the second rate communication occupies one half of the capacity occupied by the first rate communication.

10. The method in claim 1, further comprising:

assigning the second rate communication to a traffic channel currently supporting another second rate communication.

11. The method in claim 1, further comprising:

compiling a list of dual rate mobile stations having the capability to communicate using either the first rate and the second higher rate.

12. The method in claim 11, further comprising:

employing hysteresis in the determining step.

13. A method for increasing capacity in a cellular communications system where mobile stations in cell areas communicate with corresponding base stations over traffic channels, comprising the steps of:

in response to a request to establish a traffic channel for a communication with a mobile station in a cell area, determining a traffic channel rate capability of the mobile station;

determining a cell area traffic load; and

if the cell area traffic load exceeds a threshold and if the mobile station has the capability to communicate using either a first higher rate and a second lower rate,

establishing a traffic channel for the mobile station communication at the second lower rate.

14. The method in claim 13, wherein the second lower rate is corresponds to a bit rate of 6.5 kbits/s and the first higher rate corresponds to a bit rate of 13 kbits/s.

15. The method in claim 13, wherein the second lower rate communication occupies one half of a traffic channel and the first higher rate communication occupies a full traffic channel.

16. The method in claim 13, further comprising:

switching the second lower rate communication to a traffic channel currently supporting another second lower rate communication.

17. The method in claim 13, further comprising:

compiling a list of mobile stations having the capability to communicate at both the second lower rate and the first higher rate.

18. The method in claim 13, further comprising:

if the traffic load at the cell area decreases below a threshold, establishing a traffic channel for the mobile station communication at the first higher rate.

19. The method in claim 18, further comprising:

employing hysteresis in the determining step.

20. The method in claim 13, further comprising:

if the traffic load at the cell area exceeds a threshold, examining first rate traffic channel connections and changing one of the first rate traffic channel connections to a second rate traffic channel.

21. In a cellular communications system where mobile stations communicate over traffic channels with base stations, each base station having a corresponding cell, a

controller coordinating the setup of a first rate traffic channel for a communication with a mobile station being served by a base station, comprising:

a memory storing traffic channel rate capabilities of plural mobile stations served by the base station, and

data processing circuitry, connected to the memory, programmed to perform the following tasks:

determining a traffic load at the cell corresponding to the base station, and

if the traffic load at the cell exceeds a threshold, reassigning the communication to a second lower rate traffic channel.

22. The controller in claim 21, wherein the mobile station has the capability to communicate over first and second rate traffic channels.

23. The controller in claim 21, wherein the data processing circuitry executes an intra-cell handover of the communication from the first rate traffic channel to the second rate traffic channel.

24. The controller in claim 21, wherein the second rate is corresponds to a bit rate of 6.5 kbits/s and the first rate corresponds to a bit rate of 13 kbits/s.

25. The controller in claim 21, wherein the second rate communication occupies one half of the capacity occupied by the first rate communication.

26. The controller in claim 21, wherein the data processing circuitry assigns the second rate communication to a traffic channel currently supporting another second rate communication.

27. The controller in claim 21, wherein the memory stores a list of dual rate mobile stations having the capability to communicate using either the first rate and the second higher rate.

28. The controller in claim 21, wherein if the traffic load at the cell area exceeds a threshold, the data processing circuitry sets up new second rate traffic channels in response to channel requests involving mobile stations in the cell area.

29. The controller in claim 21, wherein the controller is located in a base station controller coupled to plural base stations.

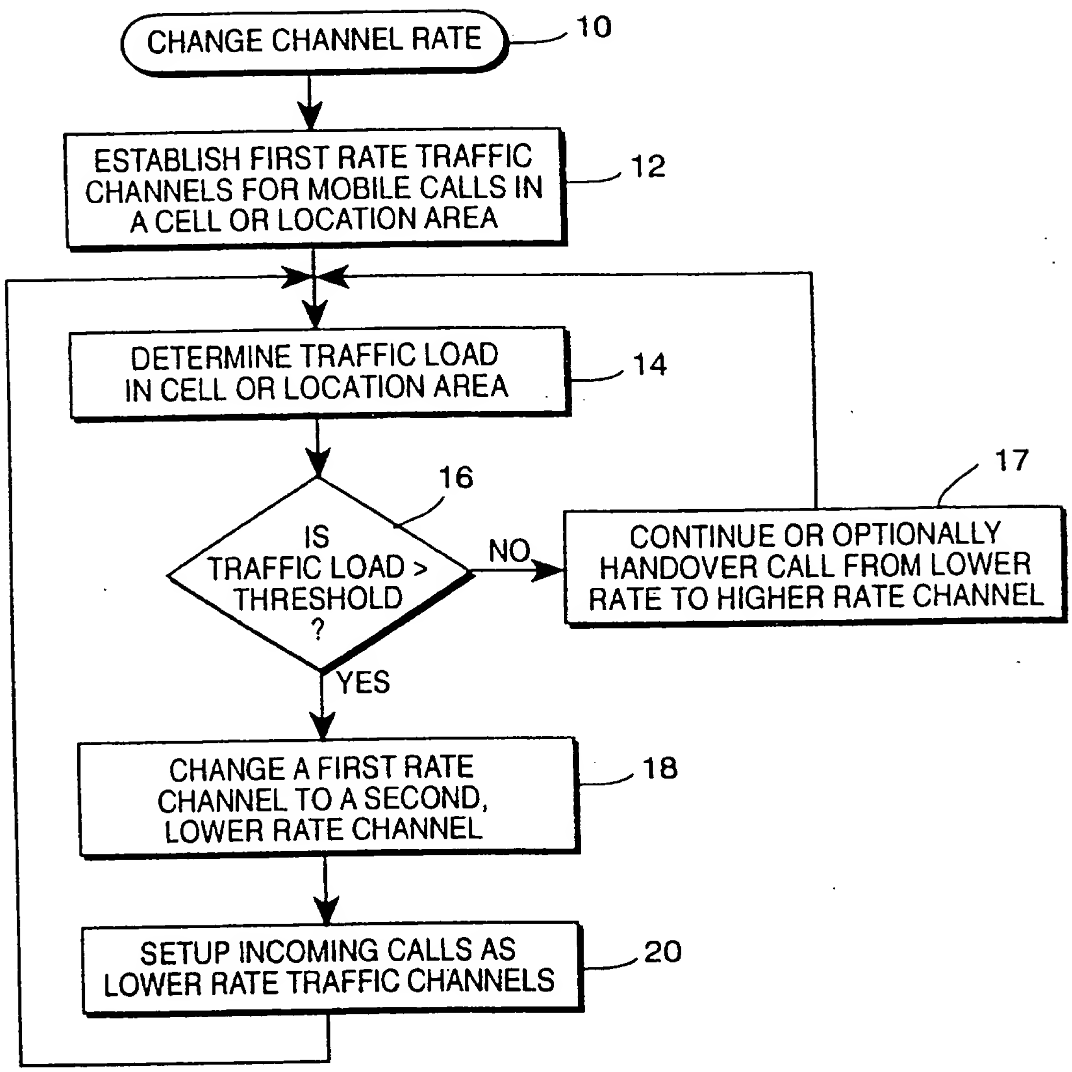
30. The controller in claim 21, wherein the controller is located in a mobile switching center coupled to plural base stations.

31. The controller in claim 21, the data processing circuitry comprising:

a counter for counting the number of busy traffic channels, and

a comparator for comparing an output from the counter to the threshold.

Fig. 1


CHANGE CHANNEL RATE
10
ESTABLISH FIRST RATE TRAFFIC CHANNELS FOR MOBILE CALLS IN A CELL OR LOCATION AREA
12
DETERMINE TRAFFIC LOAD IN CELL OR LOCATION AREA
14
16
IS TRAFFIC LOAD > THRESHOLD ?
NO
17
CONTINUE OR OPTIONALLY HANDOVER CALL FROM LOWER RATE TO HIGHER RATE CHANNEL
YES
CHANGE A FIRST RATE CHANNEL TO A SECOND, LOWER RATE CHANNEL
18
SETUP INCOMING CALLS AS LOWER RATE TRAFFIC CHANNELS
20

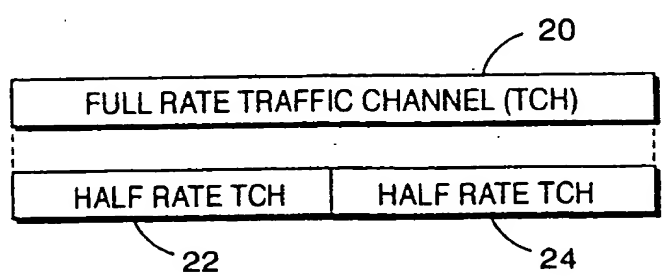

20
FULL RATE TRAFFIC CHANNEL (TCH)
HALF RATE TCH
HALF RATE TCH
22
24

Fig. 3

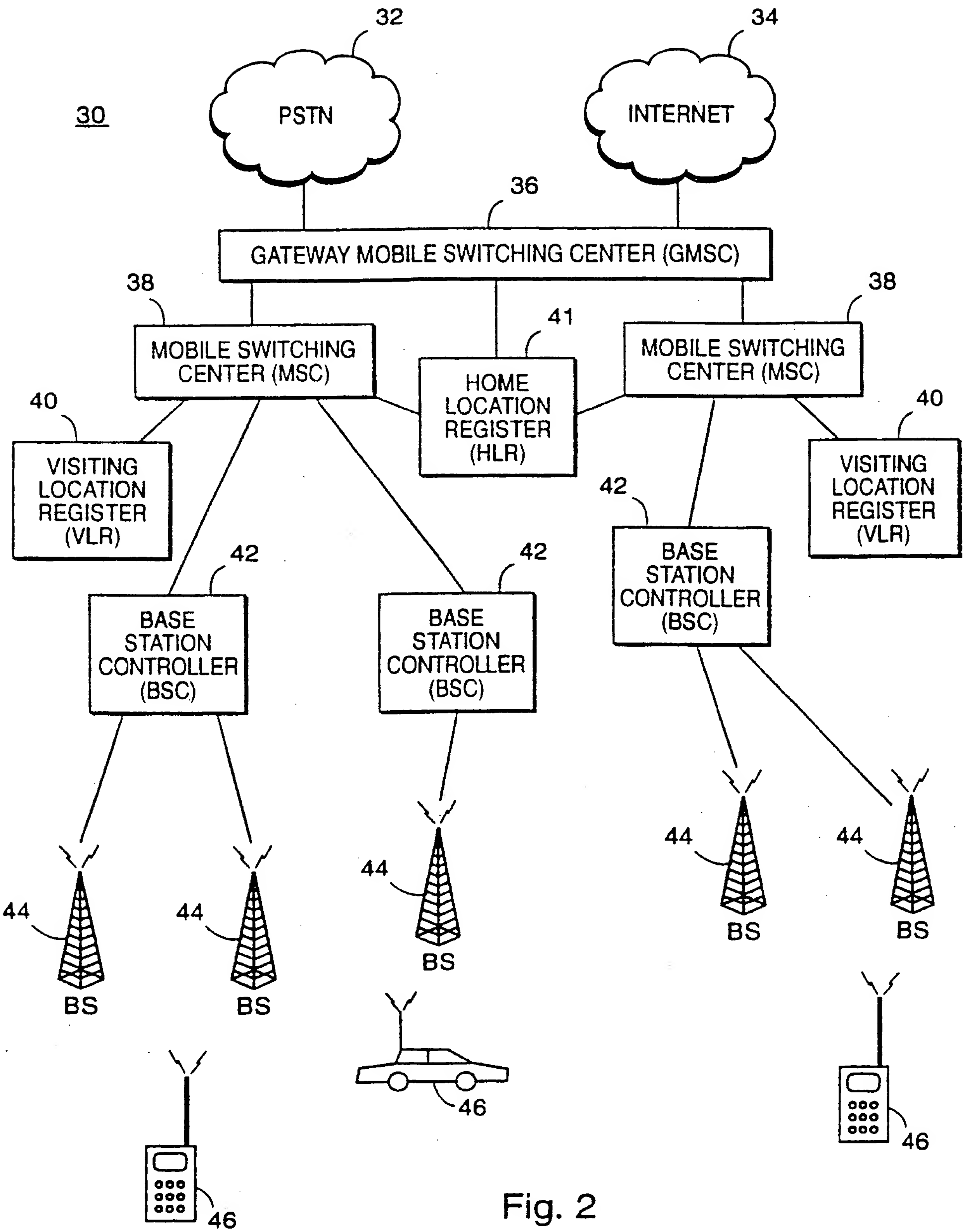

32
34
30
PSTN
INTERNET
36
GATEWAY MOBILE SWITCHING CENTER (GMSC)
38
38
41
MOBILE SWITCHING CENTER (MSC)
HOME LOCATION REGISTER (HLR)
MOBILE SWITCHING CENTER (MSC)
40
40
VISITING LOCATION REGISTER (VLR)
VISITING LOCATION REGISTER (VLR)
42
42
42
BASE STATION CONTROLLER (BSC)
BASE STATION CONTROLLER (BSC)
BASE STATION CONTROLLER (BSC)
44
BS
46

Fig. 2

Fig. 4

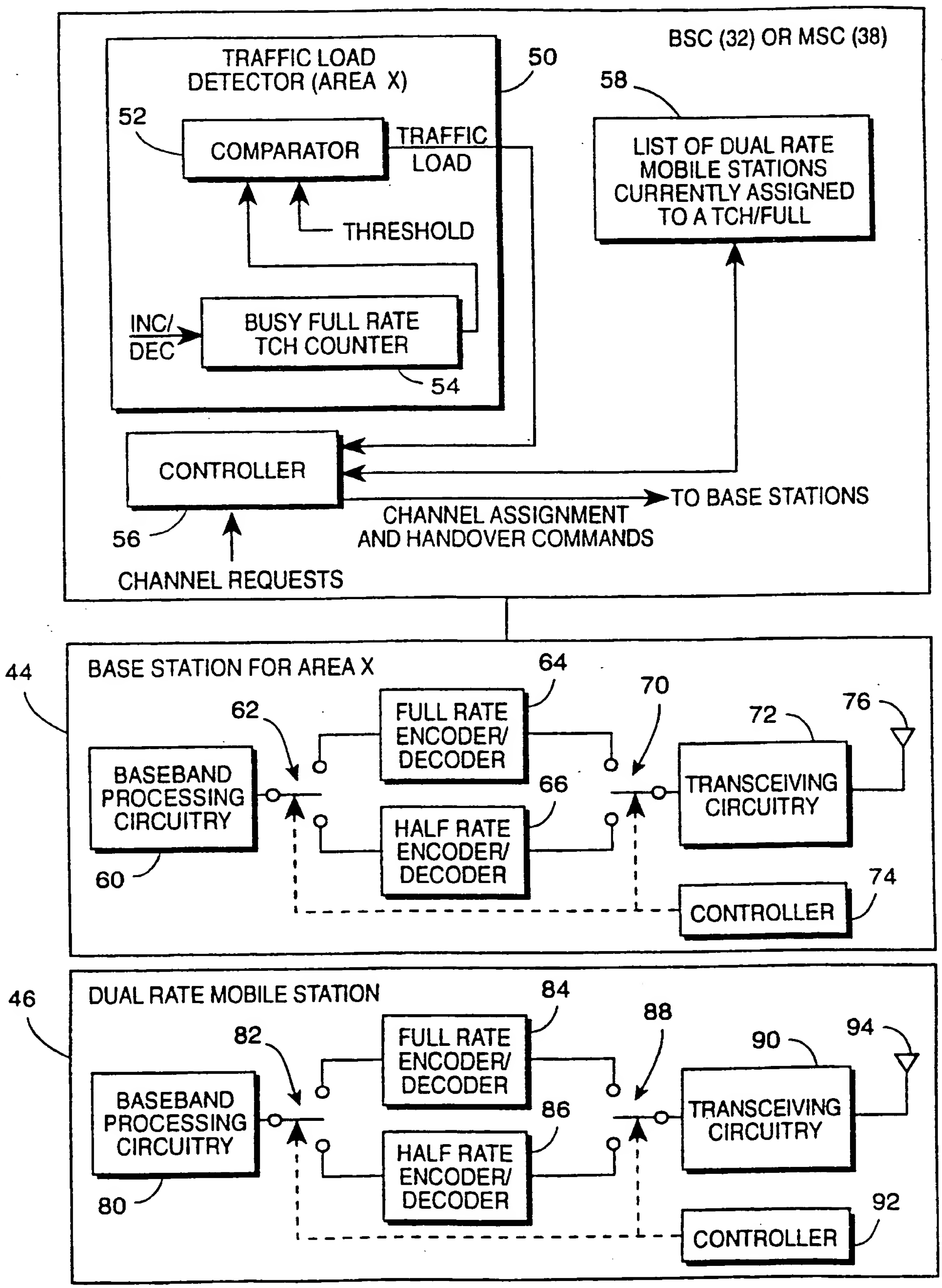

BSC (32) OR MSC (38)
TRAFFIC LOAD DETECTOR (AREA X)
50
52
COMPARATOR
TRAFFIC LOAD
THRESHOLD
INC/ DEC
BUSY FULL RATE TCH COUNTER
54
58
LIST OF DUAL RATE MOBILE STATIONS CURRENTLY ASSIGNED TO A TCH/FULL
CONTROLLER
56
TO BASE STATIONS
CHANNEL ASSIGNMENT AND HANDOVER COMMANDS
CHANNEL REQUESTS
44
BASE STATION FOR AREA X
64
62
70
72
76
BASEBAND PROCESSING CIRCUITRY
FULL RATE ENCODER/ DECODER
66
HALF RATE ENCODER/ DECODER
TRANSCEIVING CIRCUITRY
60
74
CONTROLLER
46
DUAL RATE MOBILE STATION
84
82
88
90
94
BASEBAND PROCESSING CIRCUITRY
FULL RATE ENCODER/ DECODER
86
HALF RATE ENCODER/ DECODER
TRANSCEIVING CIRCUITRY
80
92
CONTROLLER

Fig. 5A

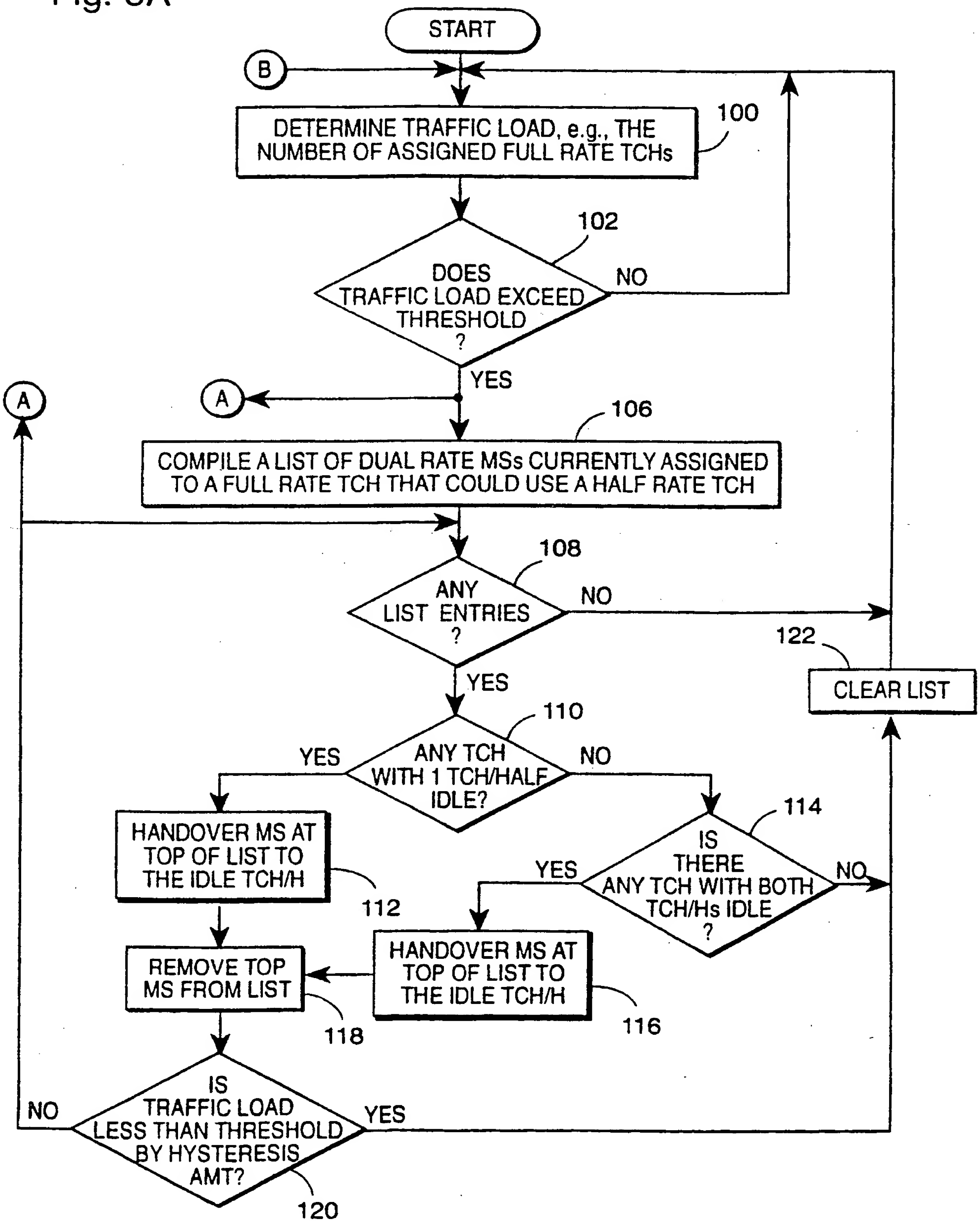
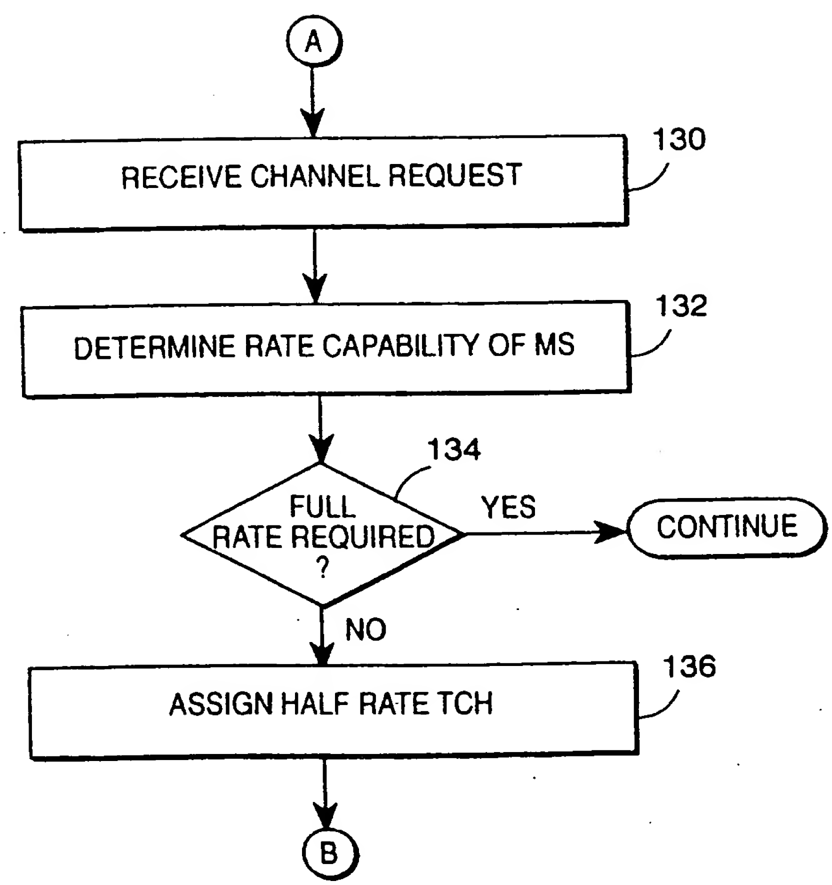

START
B
DETERMINE TRAFFIC LOAD, e.g., THE NUMBER OF ASSIGNED FULL RATE TCHs
100
DOES TRAFFIC LOAD EXCEED THRESHOLD ?
102
NO
YES
A
A
COMPILE A LIST OF DUAL RATE MSs CURRENTLY ASSIGNED TO A FULL RATE TCH THAT COULD USE A HALF RATE TCH
106
ANY LIST ENTRIES ?
108
NO
YES
122
CLEAR LIST
ANY TCH WITH 1 TCH/HALF IDLE?
110
YES
NO
HANDOVER MS AT TOP OF LIST TO THE IDLE TCH/H
112
IS THERE ANY TCH WITH BOTH TCH/Hs IDLE ?
114
YES
NO
HANDOVER MS AT TOP OF LIST TO THE IDLE TCH/H
116
REMOVE TOP MS FROM LIST
118
IS TRAFFIC LOAD LESS THAN THRESHOLD BY HYSTERESIS AMT?
120
NO
YES

Fig. 5B


A
RECEIVE CHANNEL REQUEST
130
DETERMINE RATE CAPABILITY OF MS
132
134
FULL RATE REQUIRED ?
YES
CONTINUE
NO
ASSIGN HALF RATE TCH
136
B

INTERNATIONAL SEARCH REPORT

Intern .al Application No
PCT/SE 99/00337

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04Q7/30

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 95 07578 A (QUALCOMM INCORPORATED) 16 March 1995 see page 5, line 14 - page 9, line 13 see page 11, line 26 - page 15, line 10; figures 1-5,11-13	1-6,9, 12,13, 15, 18-22, 25,28-31
A	WO 95 12257 A (MOTOROLA INC.) 4 May 1995 see the whole document	1-6,9, 11-13, 15, 17-19, 21,22, 25,27-31

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 May 1999	07/06/1999
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Verleye, J

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Intern: al Application No
PCT/SE 99/00337

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